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HARRIS HYDROELECTRIC SYSTEMS

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HOW TO DETERMINE SYSTEM OUTPUT

System output is determined by a variety of factors;

1. Head, or drop in elevation from source of water to turbine nozzle.

2. Flow, or number of gallons per minuite passing thru nozzle.

3. Diameter, length, and condition of feeder pipe.

4. Turbine efficiency.

A precise output figure is difficult to determine. Silt may accumulate in dips in the pipe and reduce output significantly. Leaks, clogging at mouth, or excessive bending of pipe may do the same. Generally single nozzle systems with under 2000 feet of feeder pipe require a 2" pipe; 2 nozzle systems need a 3" pipe; 4 nozzlessystems want a 4" pipe. Longer pipes must be larger and shorter ones can be slightly smaller. Output and efficiency are always improved by increasing pipe diameter. Very high head systems (over 250 feet) can use pipe down to 1" dia. but flow is greatly reduced and friction losses are high.

The following system may be used to approximate output. It assumes a relatively straight, clean plastic pipe. Steel pipe will have about twice the frictional losses.

1. Determine head.

This may be done by measuring the vertical drop with a measuring stick of known legnth and a carpenters level. Place the stick on the ground at the turbine site and put the level squarly on top of it. Site along the bottom of the level to the spot where it intersects the ground and move the stick to that point. This process is repeated until the dam site is reached, and the stick legnths are all added together. Subtract 1 foot for the distance the nozzle will be above the ground. If a pipe is already installed, the pressure can be measured directly.

2.3 feet =1 lb/sq" .43 lbs=1 foot

An alternative method is to string a number of hoses together, fill them with water, and measure the pressure. This can be done in several steps, and the figures summed.

2. Determine flow.

On small creeks, atemporary dam can be erected to divert the flow into a container of known volume and timing it. Small creeks should never be dried up as environmental damage will likely result. On larger creeks, flow is limited only by the size of the pipe. Many creeks rise and fall seasonally and it is important to know the low figure. The nozzle size can be reduced for periods of low flow.

The maximum output of a given pipe is usually obtained when friction losses are about 1/3 of the static pressure. Maximum efficiency is obtained with the largest pipe possible.

3. Measure the legnth of pipe needed or installed.

4. Determine head loss from the following table.

G.P.M.	1"	2"	3"	4"
5	.8	.2	.1	0
10	1.6	.4	.2	.1
15	3.2	.7	.4	.2
20	4.8	1.0	.5	.3
25	6.5	1.5	.7	.4
30	9.5	2.0	1.0	.5
40	-	3.2	1.5	.7
50	-	5.0	2.1	1.0
100	-	-	4.7	2.0

Pipe size

Losses per 100 feet of pipe

5. Multiply the figure found in table times number of 100 foot Pipe sections needed.

6. Subtract this figure from the static head (# 1) This is dynamic or net head.

7. Multiply net head times flow in gallons per minuite times .08 for Delco systems; or N. H. times G. P. M. times .10 for permanent magnent systems. These are average figures and will be better in some cases and worse in others depending on site conditions. P. M. generator systems are suitable only for sites from 75 to 200 feet of head. To get amp output divide above figure by 12.

Permanent Magnet Output Chart

G.P.M.	Feet of head		
	75	100	200
2	—	—	40
5	—	35	100
10	40	85	200
15	60	125	300
20	85	175	400
30	150	300	500
50	225	500	—
100	450	—	—

Delco Alternator Output Chart
(Pipe losses not included)

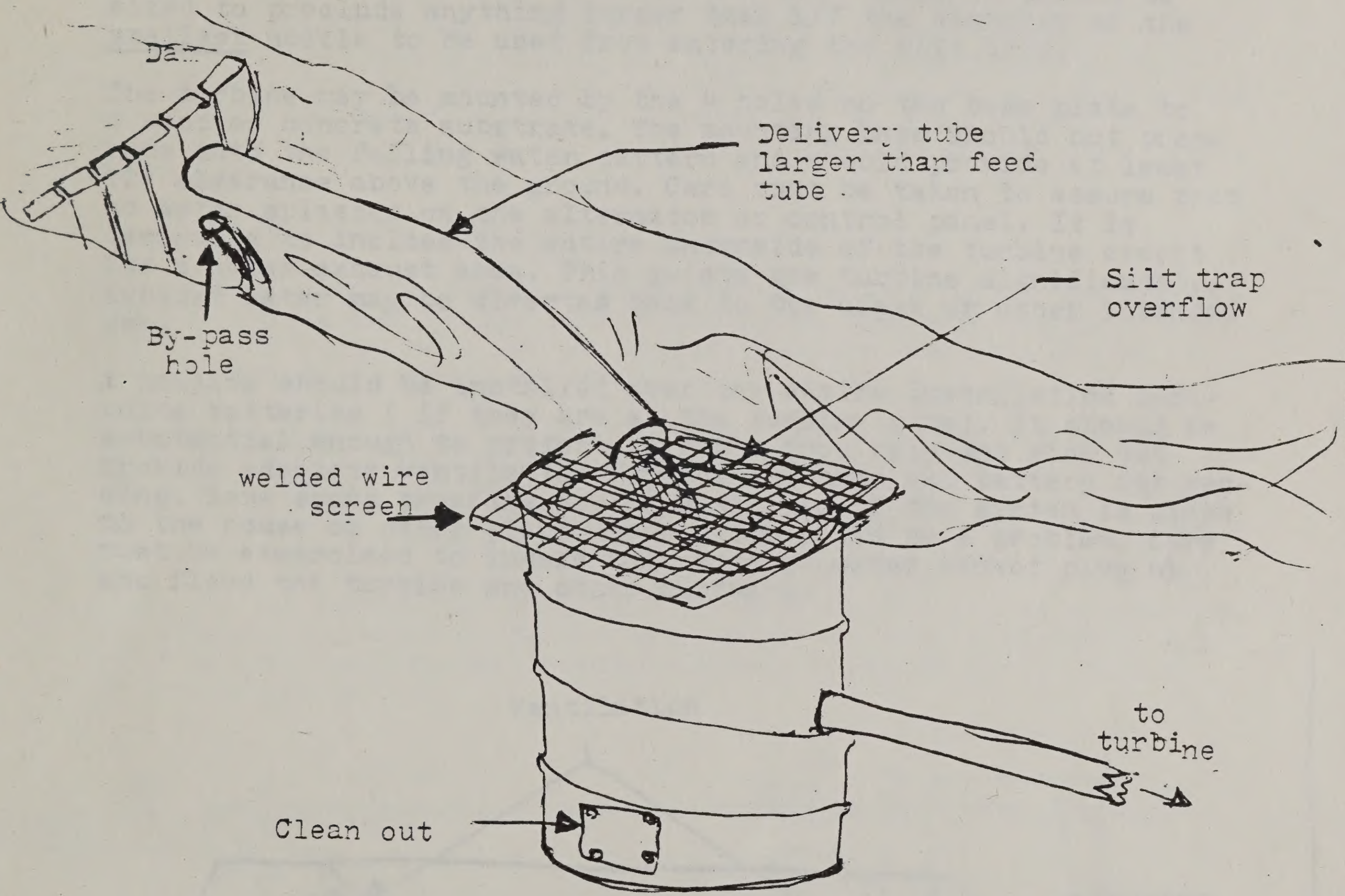
G.P.M.	Feet of head					
	50	75	100	200	300	600
2	—	—	—	20	50	100
5	—	—	25	70	120	250
10	—	30	70	150	240	500
15	—	50	100	210	375	—
20	40	80	150	320	500	—
30	70	120	220	500	—	—
50	100	200	350	—	—	—
100	200	400	500	—	—	—

Output figures in watts

INSTALLATION

After determing head and flow and deciding the proper pipe size, a water diversion must be installed. It is prudent not to remove too much water during the dry season from a flowing creek as undesirable changes in the creek bed can result. A dam that allows a minimal flow to pass before the turbine feed pipe gets water will accomplish this. This will also reduce the amount of silt in the pipe.

If the stream becomes silty during the wet season, a silt trap should be installed. A small Dough-Boy type pool is excellent but a 55 gallon drum will do.



In very low springs or creeks during the dry season the turbine can be run intermittently by trickling water into the pool for a day or 2 then running it at a much higher rate for an hour or so. This can be made automatic with a double acting float valve.

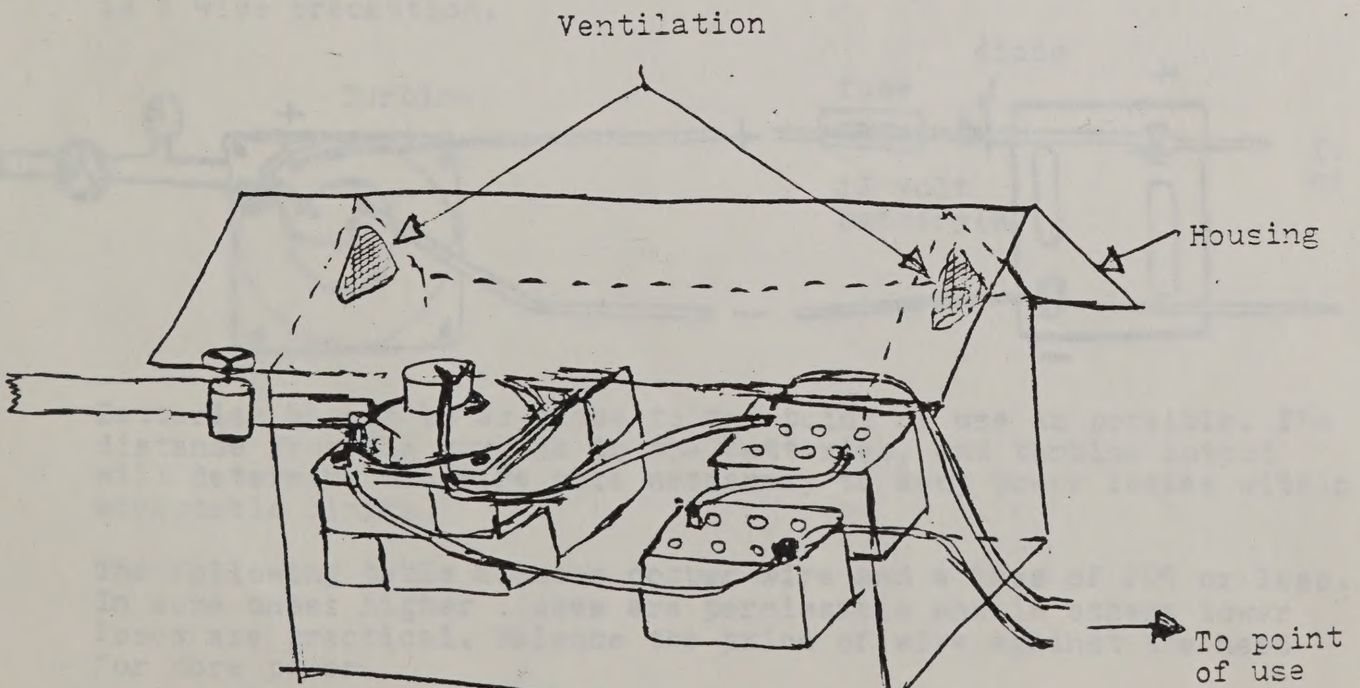
Next, the pipe must be laid, being careful not to stress the pipe excessively. If laid above ground, plastic pipe tends to deteriorate in direct sun light. Covering pipe with a layer of leaves etc. will solve this. Pipe in steep country should be well anchored as slippery plastic pipe tends to slide down hill.

Cleanouts should be provided in dips in the pipe where silt tends to accumulate and in long pipes air relief valves should be put at humps. Be careful to get pipe capable of withstanding the pressure you will have plus at least 50 lbs. This is because when the system is shut down either intentially or by an obstruction in the nozzle, the pressure rises substantially. Valves should always be closed slowly. It is advisable to permanently install a pressure gauge in the line at the turbine end but before the gate valve. It will be invaluable in trouble shooting hydrolic problems.

Welded wire may be used to cover the silt trap. It should be sized to preclude anything larger than 1/2 the diameter of the smallest nozzle to be used from entering the silt trap.

The turbine may be mounted by the 4 holes on the base plate to a wood or concrete substrate. The mounting base should not protrude into the falling water pattern and should provide at least 12" clearance above the ground. Care must be taken to assure that no water splashes on the alternator or control panel. It is desirable to inclose the entire underside of the turbine except for a water exhaust area. This quiets the turbine significantly. Exhaust water may be diverted back to the creek or other intended use.

A housing should be installed over the entire installation including batteries (if they are at the turbine site). It should be substantial enough to protect hardware from rain and wind but provide adequate ventilation for turbine heat and battery out gassing. Some sound proofing may be desirable if the system is close to the house or other place where noise could be a problem. Care must be excercised to insure that exhaust water cannot plug up and flood the turbine and other hardware.

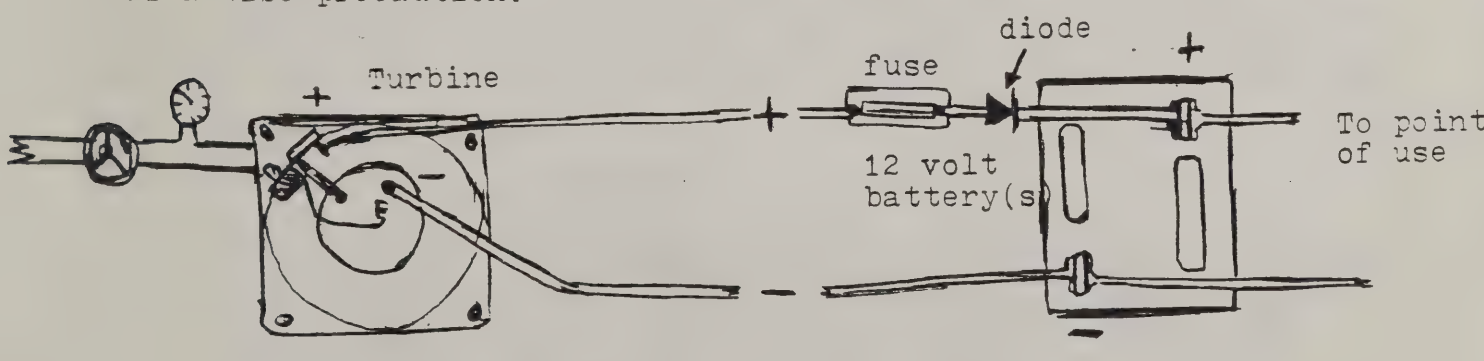


In most instillations, battery capacity should be at least 25 times the generator output. For example, a system that produces 100 watts or about 8 amps should have at least 200 amp-hour capacity. Deep cycling batteries are preferable to automobile type because of their longer life and lower life cycle cost. On Delco systems under 100 feet of head a standard automotive voltage regulator can be inserted in series with the field before the rehostate if the batteries are within 10 feet of the turbine and at least #10 wire is used. Systems with over 100 feet of head or remote battery location need a load diversion-dummy load type regulator. Careful management, proper matching of output (by proper nozzeling) with electrical energy needs, and regular inspection of battery condition and water will allow no aditional regulation. The system can simply be used to charge the batteries an then turned off. Regulation is appropiate for systems in continuous use with little attention.

BE CAREFUL NOT TO REVERSE POLARITY !!

Simply touching the battery backwards on Delco equiped systems can destroy the diodes in the alternator. P.M. generator systems that are reverse wired will run as motors, running down the battery, but no permanent damage is done.

A blocking diode with a capacity of at least 30 amps should be inserted in the line, preferably near the batteries, to prevent battery drainage when the system is shut down. P.M. generator systems are already so equiped, but Delco systems are not. On systems producing over 10 amps the diode should be mounted to a suitable heat sink. It is also wise to place a 30 amp fuse in the line as close to the battery(s) as possible. Electricity can be dangerous! All connections must be secure and placed at a safe distance from any flamable conditions. Burying electrical transmission lines is a wise precaution.



Batteries should be as close to the point of use as possible. The distance from the turbine to the batteries, and turbine output will determine the wire size necessary to keep power losses within acceptable limits.

The following table assumes copper wire and a loss of 20% or less. In some cases higher losses are permissable and in others lower loses are practical. Balence the price of wire against the need for more power.

	50'	100'	150'	200'	250'	300' ← distance in feet
2	#12	#12	#12	#12	#12	#12
5	#12	#12	#12	#12	#10	#10
10	#12	#12	#10	#8	#8	#6
Output in amps 15	#12	#10	#8	#6	#6	#4
20	#10	#8	#6	#4	#4	#4
30	#10	#6	#6	#4	#2	#2

The water that will pass thru the turbine is dependent on the nozzle size, the number of nozzles, and the net head. In a given pipe the bigger the nozzle, the lower the net head will be. This is significant in long, small diameter pipes. The flow thru a given nozzle increases with the square root of the increase in net head.

Head	7/32	1/4	5/16	11/32	7/16 Nozzle size
100'	8.3	10.3	15.5	20.7	30.8
200'	11.7	15.3	21.9	29.3	43 5
400'	16.6	21.6	31.0	41.4	61.6

Flow in G/P/M

If all this seems too complex, it is simpler and more interesting to try various nozzles and note the results!

OPERATION

Once the turbine pipe and wiring are connected, the water simply needs to be turned on. On Delco systems, the knob on the control panel regulates the magnetic field in the alternator. To operate at maximum efficiency, a pelton wheel should spin at exactly 1/2 the speed of the water hitting it. By increasing the magnetic strentn the wheel slows down and at some point reaches maximum efficiency. Simply watch the output gauge until the highest reading is obtained.

MAINTENCE

Batteries should be checked regularly for water and corrosion. If the water level is continuously low (say every week) a smaller nozzle may be appropiate to reduce output to match need. Output should be checked frequently at first. Every couple months the nozzle and runner should be inspected for signs of erosion or damage, indicating a full silt trap or a ruptured screen. The pelton runner is hard anodized aluminum and is resistant but not impervious to silt erosion. It can be damaged by small stones. The nozzle is subject to silt erosion. Excessive alternator noise may indicate a bad bearing. Radio interference may indicate a failing diode in the alternator. This will be accompained by a drop in output.

Should the wheel need to be removed for alternator repair, the following sequence should be followed.

DO NOT PRY OR HOLD PELTON WHEEL TO REMOVE IT

1. Remove 2 allen bolts holding wheelto hub and remove wheel.

2. Place an ajustable wrench on flats on hub.

3. Place a 5/16 allen wrench thru hole in hub into alternator end.

4. Turn the wrench clockwise (facing hub) while holding ajustable wrench and remove hub.

5. Remove 2 bolts and 2 electrical connections.

6. Remove alternator being careful to note and remember the sequence of spacers and water slinger on alternator shaft.

Permanent magnet system;

1. Remove allen bolt and washer at center of hub.

2. Thread a 3/8-16 bolt into the same hole and remove the entire assembly.

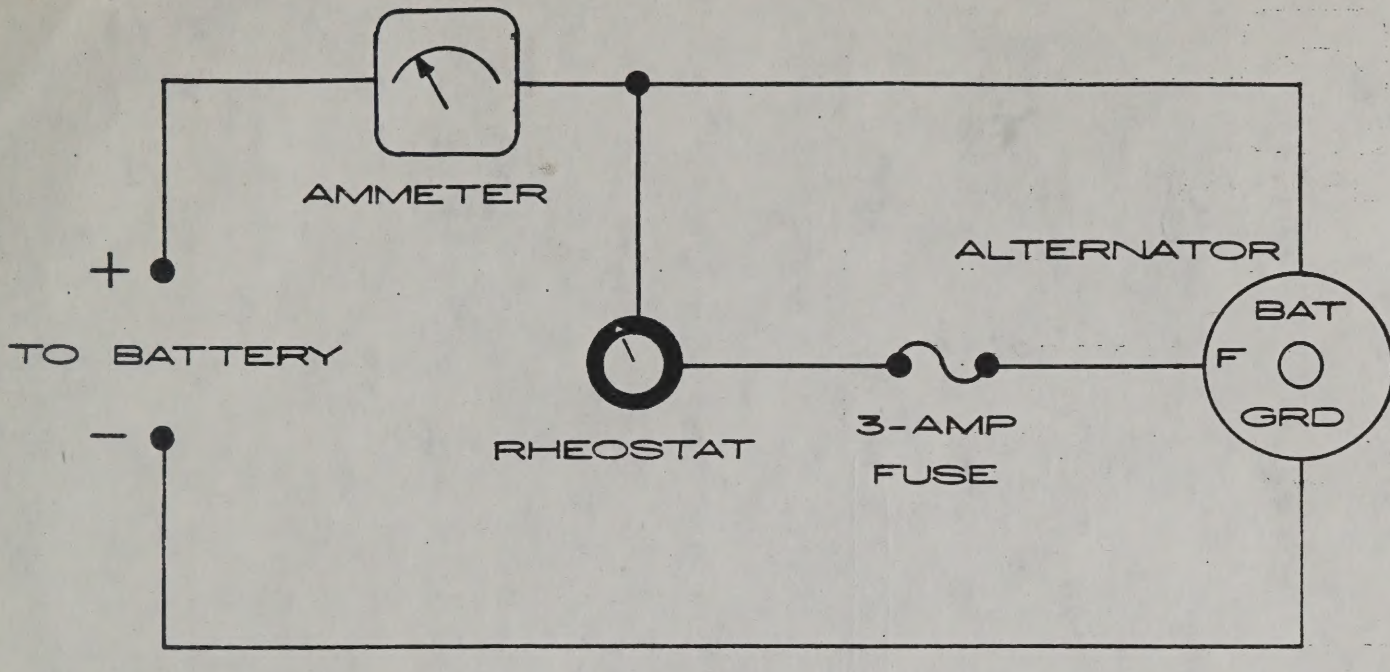
3. Remove 2 wires, 4 allen bolts, and remove generator.

Normally the nozzle is properly alligned and needs no ajustment, however, should the wheel or nozzle assembly be removed, realignment is necessary. Alignment is achieved by by varying the setting of the 2 allen set screws on the underside of the casting and the inside allen bolt on the top of the casting. The nozzle must be ajusted in 2 directions.

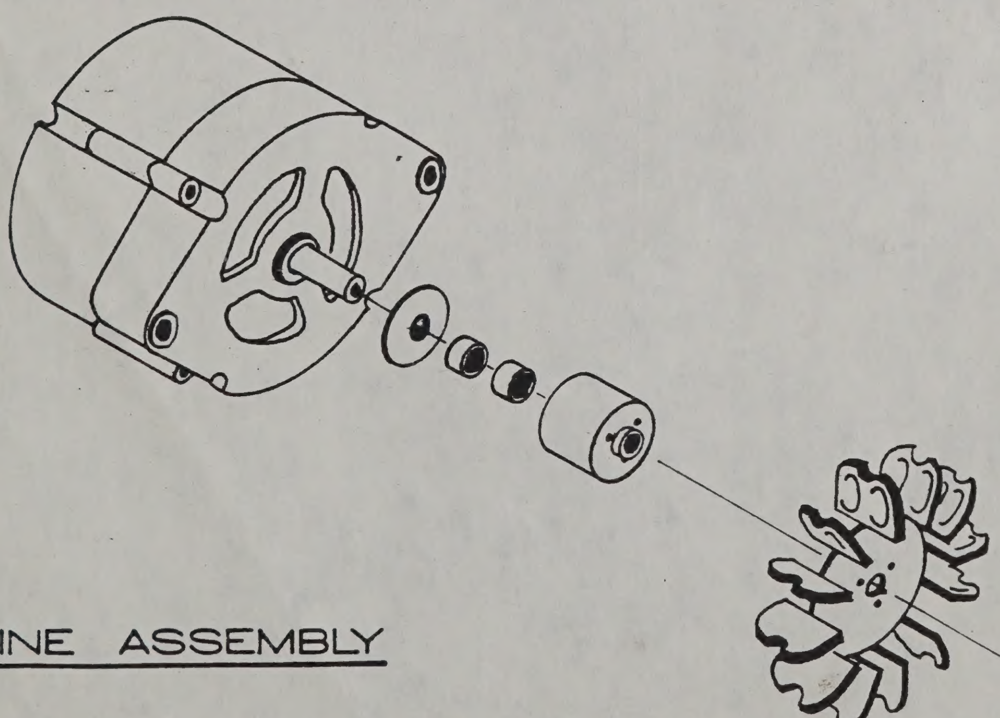
1. Horizontal ajustment; The nozzle assembly should be square(90°) to the edge of the casting. this can be measured with a carpenters square or even the corner of this page.

2. Vertical ajustment; The nozzle must be pointed exactly at the central ridge of the wheel buckets. On single nozzle systems, you can simply sight down the center of the delivery tube. On multi-nozzle systems, a special pointer alignment tool is available for $5. The tool pointer is aligned directly on the central ridge. In reality, both of these ajustments are done simaltaniously. It may take a little practice, but once mastered it is quite simple and quick.

Never disconnect the turbine from the battery during operation. This allows voltage to rise to dangerous levels and will blow the fuse in the field wire. Should the system fail to perform check this fuse. It should be replaced with a 3 amp fuse. The wires connecting the turbine to the batteries should be isolated from the wires going from the batteries to the point of use to protect the latter from high voltage spikes that can damage 12 volt appliances.



WIRING DIAGRAM



TURBINE ASSEMBLY